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CLOSE COMBAT SUPPRESSION: NEED, ASSESSMENT AND USE

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Introduction

Modern small arms have many requirements; they must be light, easy to use, cheap, robust and reliable, amongst other things. Their primary purpose, however, is to provide the soldier with a means of defending himself, and attacking an enemy. It is no surprise, then that terminal effects are specified in terms of lethality given a hit, and the probability of hitting the target (ie accuracy).

However, infantry doctrine relies heavily on the ability to suppress targets, but it has not been possible to lay down a requirement for suppressive capability due to the lack of a robust criteria and means of assessment.

This paper describes the work carried out within DERA to develop a suppression criteria to assist in the study of infantry weapon system concepts, and a trials methodology to assess various weapon systems. It also aims to highlight the importance of suppression as a means of assessing weapon systems performance.

Historical background

Numerous studies of the effectiveness of small arms in combat have shown that thousands of rounds are fired for each casualty caused. This has led, in the past, to the conclusion that small arms are simply not effective at producing casualties (especially when used in earnest on the battlefield), and that new systems are required to improve the capability to cause casualties.

For instance, work carried out at the Operations Research Office (ORO), John Hopkins University and the Ballistics Research Laboratories, led to the concept of a weapon that fired several projectiles at once to compensate for aiming errors (Project Salvo & the SPIW - Special Purpose Individual Weapon) and then

on to a small-calibre high-velocity concept (the M16). Both of these were aimed at enabling soldiers to hit and incapacitate more easily through new technology and novel concepts.

This logic ignores two very important points, however. Firstly, although weapons have become very much more lethal, over much longer ranges, the actual rate of casualties has not increased significantly (as stated by ORO, [1]). This is due to the fact that soldiers do not wait around to be shot; they run, take cover and shoot back. Thus any improvement in weaponry usually results in a corresponding change in tactics and enemy equipment to compensate (with occasional exceptions such as the American Civil War and the First World War - both of which saw heavy casualties).

Secondly, despite the relatively low number of casualties caused, battles are still won and lost. This would suggest that whilst modern weapons are not effective at causing casualties, they may still be effective at winning battles - 4000 rounds per casualty sounds wasteful, but is 40000 rounds per engagement won not acceptable?

The answer to this seeming paradox is the fact that most ammunition is used to suppress the enemy, in order to allow ones own troops to get close enough for their weapons to actually be effective in causing casualties. Thus, in order to gain a full appreciation of the effectiveness of a particular small arm system in combat, it is necessary to include its suppressive capability in any assessment.

Scope of suppression criteria

There are three areas where suppression models and criteria would offer a useful capability; Operational Analysis (OA), weapon systems lethality studies, and trials.

A number of models have been developed in the past[2], mainly to provide the capability to model suppression within combat simulations and wargames. None of these have been accepted as a standard for the modelling of suppression (particularly for close combat), and all use very different assumptions which leads (not surprisingly) to very different outputs. Essentially, if any one of them is correct, then all the others must be wrong [3].

The fundamental problem, however, appears to be the fact that the part suppression plays in a battle depends on the complex interaction between the properties of the different weapons and the humans that are taking part [4]. As data for these human factors issues is not easily available, OA models tend to give simple, relative outputs [3], that cannot be used to assess individual weapon concepts and systems.

No attempt appears to have been made to use suppression models in the technical assessment of weapon systems. All weapons can be expected to have some suppressive capability, and being able to quantify this, even in relative terms, would greatly assist the selection of suitable small arms (with respect to both generic concepts, and particular systems).

Finally, the ability to measure suppressive capability through trials would not only enhance the modelling of suppression, but would also give greater confidence in the choice of weapon systems.

The work carried out within WX6 focused on developing a criteria for small arms and direct fire suppression, which could then be used to derive a suppression model for systems studies, and a related test methodology for trials. It should be noted that this work was aimed only at the suppressive qualities of the weapon system, and not the effect of suppression within a battle (ie this is a technical assessment model for the weapon, rather than an OA model).

Definition of suppression

The phrase “keeping the enemy’s’ heads down”

is a very simple, but easily understood visualisation of what suppression means, particularly to an infantry man. It does not, however, provide a robust or precise enough definition from which models or techniques suitable for weapon system assessments can be developed.

NATO STANAG 4513 [5] defines suppression of the soldier as;

“...when he is unable or unwilling to carry out his task effectively, because of the actual or perceived threat, or because of fear (in particular of being wounded)”

The most important thing to note is that it only occurs when a soldier is unable to carry out his *task* - whatever that may be (command, communication or using a weapon are the three tasks listed in the STANAG). Thus a soldier who is unable to return fire, despite having been ordered to do so, can be considered to be suppressed. A junior officer taking cover and formulating an alternative plan (after an attack has stalled in the open, say) cannot be said to be suppressed, because he is still carrying out his task.

This definition does not necessarily include the demoralising effect of sustained artillery bombardment, although it will be shown later that it may be possible to use the same methodology for analysing close combat for suppression to investigate the ability of weapons to contribute to Post Traumatic Stress Disorder (PTSD).

There are two times associated with suppression; the delay from awareness of the suppressive mechanism to actual suppression, and the duration of the suppression. A soldier in combat can be suppressed for long periods of time if he is under continuous fire. Once the fire has lifted, he will stay suppressed for a certain time before reacting. This time will vary from soldier to soldier, scenario to scenario, and also occasion to occasion, and so it is often only possible to use a mean or average duration of suppression after fire lifts (or a round has passed/detonated).

Previous models

The first studies into suppression probably took place just after World War II when the suppressive effects of artillery bombardment were studied. Later studies into the suppressive effects of small arms were spurred on mainly by the need to determine how to upset the aim of an anti-tank missile operator.

This work centred either on surveys and questionnaires of combat veterans, trials or a combination of the two (a comprehensive summary of the trials and studies carried out can be found in [3]). These then led to certain models being derived from the resulting data, which were used in OA models. As mentioned before however, none of these were considered to be robust or thorough enough to gain widespread usage [3].

A number of these models were compared in [2], so only a brief discussion of their merits will be given here.

The Litton model [6] was one of the first models, and used the fractional casualties inflicted by a weapon as the parameter that effects the suppression of the remaining soldiers. Using fractional casualties as the variable is useful as it allows weapons to be assessed using models. However, the Litton model makes no allowance for other weapon characteristics (ie noise, flash etc) that could increase or decrease suppression.

The CDEC model [7] was generated from data collated from a series of trials. Soldiers were placed in pits and fired at. They were then asked to act in the way they would expect to if under actual enemy fire. This introduced an element of certainty (compared to survey) although there were doubts as to whether the artificiality of the situation would have affected the results. Here, radial miss distance was taken as the critical parameter. Coefficients were derived from trials data for each of the weapon tested. This then meant that for each weapon type a certain miss distance could be equated to suppression. The problem, however, is that it cannot be readily used in modelling as it is difficult to generate

the coefficients except through trials.

Both the models described so far predict a Probability of Suppression (PS).

The ASARs model [8] is based on further developments of the Litton studies [9]. This also uses fractional casualties as the main parameter, but rather than predicting PS, it gives the probability that a man is in one of 6 states. Each of these states relates to different levels of ability in observing, moving and firing. Thus it is possible to derive the expected number of troops under fire who are in each of these states. The problems with this particular model are that the correlation with the trials data is not as high as would be desired, and it still does not include differences for different weapon characteristics.

Allen [2] proposed a modified form of the ASARs model using the original data plus data from the CDEC experiments. The modified equation resulted in a higher correlation to the trials data, and also included a factor for different weapons.

Whilst the modified ASARs model appeared to be the most advanced means of including suppression in OA models, it still lacks the full range of Human Factors issues, such as scenario, leadership, training etc. Confidence in the suppressive effects used in wargames must, therefore, be limited. It does, however, form a useful conceptual basis for a model that looks purely at the suppressive potentials of weapon systems.

Basis of the suppression criteria

The starting point for the suppression model described here was a survey of British Army soldiers who had experienced small arms suppression in close combat [4]. This built on earlier studies and surveys to provide a very comprehensive view of the different parameters that lead to suppression, including those dependent on Human Factors. Most interesting were the statements made concerning the ability of certain weapon to suppress in certain scenarios.

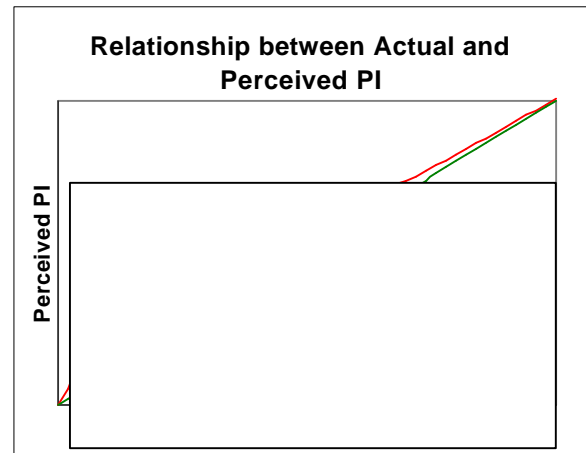
By modelling the scenarios included within the survey, it was possible to identify the Probability of Incapacitation (PI) inflicted by each type of weapon. Then by comparing these PIs with the views of which weapon do and do not suppress, a threshold PI was found, above which a man is suppressed, and below which he is not. This threshold, however, is only valid for the soldiers used in the survey, and the weapon parameters used.

The concept of Perceived PI (PPI) or Perceived Risk (PR) was then suggested, whereby when a soldier comes under fire, he makes an subconscious assessment of his PI, or risk (ie he evaluates PPI). If the PPI exceeds a certain value (ie the soldier concludes that his PI is above an acceptable limit), he then takes such action as to reduce his PPI (ie he becomes suppressed because he is doing something other than his job, such as ducking, taking cover or retreating). The threshold PPI above which he becomes suppressed is a constant for a particular soldier, so it enables comparisons to be made of different weapon systems.

The key to this is the relationship between PPI and PI, and this is closely linked to the expectation and awareness of the event that causes the soldier to feel suppressed (eg the crack of the bullet overhead, the kicking up of soil as a bullet hits the ground, and the bang and flash of an explosive round detonating nearby).

A veteran will usually have a PPI that is much closer to his actual PI than a new recruit. However, his ability to correctly judge his PI is also affected by the characteristics of the weapons, as illustrated opposite.

For a system with a very low PI (eg IW), a soldier's PPI will also be very low, so he is unlikely to be suppressed. Against a weapon with a very high PI (eg artillery) the soldier's PPI will also be very high so he will be suppressed. In both these cases, however, his PI and PPI will be very close together. In the former case he knows he is at little risk, due to the weapon's inadequacy, whilst in the latter case he estimates his risk is very high, because it is actually very high.

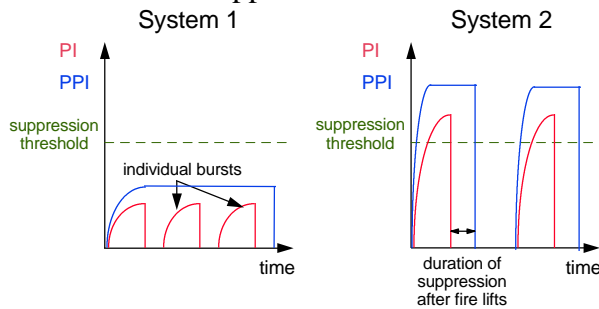


With certain weapons, however, a soldier is unable to accurately predict his PI, hence the PPI is very different (usually much higher) than his actual PI. These weapons are usually those with medium PI, where the soldier knows that he will become a casualty if he is hit, but cannot judge the likelihood of being hit. HMGs and GPMGs are two of the weapon types that come under this category, because although their actual PI is low their terminal effects and large aural and visual signatures make the soldier very aware he is under attack and uncertain of the likelihood of being hit. Hence his PPI is much higher than it needs to be.

One of the benefits, therefore, of suppression criteria for a weapon system is the ability to determine what characteristics it needs to have to maximise the suppressive effects, for a given lethal effect (which is somewhat easier than constantly trying to improve terminal effects in the face of body armour and field fortifications).

The remaining parameter, duration of suppression, is more complicated, as it depends on the proximity of the enemy and the scenario. If, for instance, a man in a trench is being shot at from 800m, by an enemy he knows is static, he is likely to stay suppressed for a longer time following the shot, than if the enemy is at 300m and moving towards him. In the latter case, if he does not get up and fire back the enemy will eventually close to within a distance from where he can assault the trench. Thus the man in the trench must balance the risk of being shot if he tries to fire back, and the risk of being hit when the enemy assaults the trench.

The graphs below illustrate the basic concepts behind the new suppression criterion.



System 1 corresponds to an individual weapon, whilst System 2 corresponds to a support weapon. System 1 achieves a very low PI per burst, due to inaccuracy, hence the PPI is very low. System 2 achieves a higher PI (and exceeds the suppression threshold), so that during the burst the PPI is such that the soldier decides to take action to avoid being hit (ie he becomes suppressed). A little while after the burst is completed he ceases to be suppressed, until a second burst is fired. Hence, for any given period of time, it is possible to calculate the percentage of that time that a soldier is suppressed, based on the duration of suppression, and the rate of fire of the weapon.

These basic concepts led to the Close Combat Suppression Model (CCSM), to be used primarily in system studies, and the Suppression Measurement Methodology (SMM), which offers a means for testing suppressive capability.

Close Combat Suppression Model (CCSM)

The CCSM contains two important elements that allow weapon suppressive ability to be predicted. Firstly, it provides an equation linking a soldier's perception of his PI (ie his PPI) to his actual PI, based on his awareness of the threat based on aural and visual stimuli. Secondly, it provides a means of actually calculating the aural and visual stimuli factors that affect his PPI.

The CCSM has as its basis, therefore, the following expression;

$$PPI = f(PI, ASF, VSF),$$

where ASF = Aural Signature Factor (relative to baseline), and VSF = Visual Signature Factor (relative to baseline).

The terms for ASF and VSF account for the soldier's awareness of being under threat, and are based on the noise, flash and dust caused by the ammunition, relative to those caused by a baseline system.

To derive the function relating PPI to PI, ASF and VSF, it was necessary to make use of work by Allen [2] in converting the CDEC and Litton experimental data to a common basis, and to ensure that the results fitted the observations from the trials (such as those relating to the ability to correctly estimate PI discussed above).

Several combinations of equations for PPI, and the aural and visual signature terms were used, with various coefficients, in order to find the values which gave the same value of PPI for all weapon systems. This equates to the threshold PPI when the target will stop carrying out his task in order to reduce his PPI (ie when he becomes suppressed).

With the CCSM it is now possible to use the suite of models within DERA to predict the aural and visual signatures of the weapon, and by using the systems lethality model (FragSys) and Scenario Weighted Incapacitation Score (SWIS) methodology [10] to determine the ability of the weapon to suppress a range of personnel targets. It can also be used to determine the suppressive capabilities of two designs which deliver the same level of incapacitation, in order to choose between them; given that most ammunition is used to suppress, this will be a truer indication of its utility on the battlefield.

It has been used in the FIST Infantry Section Incapacitation and Suppression Study (SISS), to help assess the balance of suppression and incapacitation capability required by the section.

Suppression Measurement Methodology (SMM)

The CCSM described above provides a predictive capability that is particularly useful in investigating weapon concepts and assessing requirements. There is also the need, however, to test whether a real weapon system is capable

of meeting the required level and duration of suppression within any particular scenario.

The SMM provides a means to conduct practical tests, and makes use of the CCSM criterion (although it can be used equally well with any of the other suppression models, particularly the CDEC model).

From the CCSM, it is possible to calculate the PI necessary to cause the PPI to exceed the threshold, and therefore suppress the target (based on the aural and visual signatures of the weapon). Then, the area into which the round must fall to cause this PI (against the specified target) must be found, from a knowledge of the terminal effects of the warhead. This is known as the Suppressive Area (SA) of the round.

The requirement for the weapon in the trial, therefore, is to be able to put at least one round into the SA every “ DS/T ” seconds, where DS = duration of suppression after the round has passed, and T = the number of targets being engaged.

The weapons are fired in short bursts, with targets being switched every $DS/2$ seconds, for a fixed length of time (5 minutes, say). Whilst firing, the number of bursts (NB) and number of rounds fired (NR) should be noted, and the number of hits within the SA (NH). The time at which magazine/drum changes take place, along with any stoppages should be noted.

A number of parameters can now be calculated. The crudest measure is the number of rounds fired within the time limit (ie NR). The ability to pour large numbers of rounds onto an enemy position has often been considered the prime requirement (and corresponds to the concept of “weight of fire”). To do this requires a high rate of fire, and whilst the visual and aural signatures of a high rate of fire weapon have an acknowledged effect on the morale of the troops firing the weapon, its effectiveness at the target is suspect. This is because the firer lacks control of the weapon and this means that only a few rounds actually hit the target.

A better measure is the number of rounds that

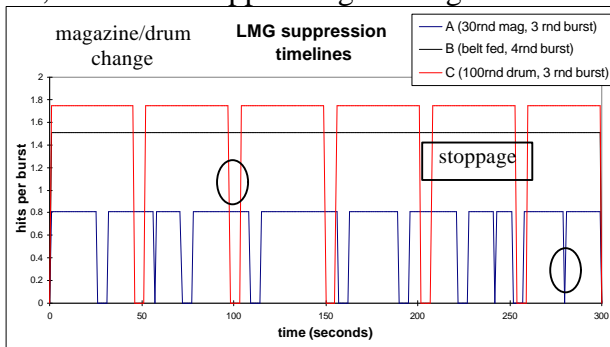
actually hit the target within the time (ie “effective weight of fire” = NH). Often a weapon with a slightly slower than average rate of fire will get more rounds onto the target, as will a weapon that is very comfortable to fire. A weapon that achieves a high number of hits on the target (each of which represents a suppressive shot) within this particular time limit will, for a fixed number of rounds, be able to suppress the target over a longer engagement period (ie it can fire one suppressive round every “ DS/T ” seconds, and continue doing this for a longer time than an inaccurate weapon).

The round number efficiency (ie percentage of rounds fired that hit the SA = $(NH/NR) \times 100$) is an indication of the potential of the weapon to suppress over a period of time, and gives an indication of the number of rounds that need to be fired per burst to hit the suppressive target at least once. This can be converted into the mass efficiency (the number of suppressive shots per kg of ammunition, including magazine/belt). A caveat to these two parameters, however, is that they give the potential suppressive capability based on their current performance, and is not an absolute indication of their current suppressive performance. This is due to the fact that the doctrine concerning the number of shots in the burst etc is not necessarily the optimum method of employment for all weapons. Hence, performance can only be maximised by developing the proposed firing techniques.

The way in which the actual performance of the weapon tested can be assessed is to investigate the system performance over the total time period, with respect to the number of hits (ie suppressive shots) per burst. From this it is possible to see whether suppression was achieved at all for each burst (given the length of burst for each weapon) and also when breaks in the firing occurred due to magazine changes or stoppages. It can also be used to optimise the burst length to maximise efficiency.

The graph below gives an illustrative suppression timeline for three hypothetical Light Machine Guns (LMGs); one magazine fed, one belt fed and one drum fed.

Weapon A gives only 0.8 hits on the target, with a burst of 3 rounds. Thus it would be necessary to have a burst of at least 4 rounds to have one hit per burst (assuming a four round burst does not have a significantly worse dispersion than a 3 round burst). Weapon C, however, gets 1.5 hits per 3 round burst on average, so could afford to reduce the burst length to 2 rounds whilst still getting one round per burst into the SA, and hence suppressing the target.



Weapon B, being belt fed, has no stops during firing. As it also exceeds one hit per burst, it can be said to be fully suppressing the targets for 100% of the total time. The other two systems require stops during which a drum or magazine is changed. By subtracting the total time taken to change drums or magazines during the time period, it is possible to calculate the percentage of the time they were firing (and hence available to provide fire support, for instance).

To give a final, standardised, comparison between the systems it is possible to convert the results into those for a fixed mass of ammunition and feeds (ie drums, magazines or links), or a fixed number of rounds. Therefore, using the optimum length of burst, it is possible to determine the length of time that the necessary level of suppression can be achieved for a given weight limit or front line scales - "carried suppression duration".

This technique was assessed in a trial carried out at the Infantry Trials and Development Unit (ITDU), and the way in which it was possible to relate the simple data collected into meaningful battlefield parameters was felt to be very useful. Indeed, this appears to be the first time that it has been possible to assess suppressive effects in a quantitative fashion, without the use of live subjects (with their attendant ethical and cost

issues).

Duration of suppression

This parameter has not been fully addressed in the work so far, as there appears to be no experimental work that can be taken as a starting point. As already mentioned, for close combat this time is a balance for the soldier between the risk of being hit by the suppressive weapon whilst returning fire, or being hit by an enemy closing, unimpeded, on his position.

Currently, both the CCSM and SSM use a fixed value based on a median value found from the recent survey [4], discussions with other military officers and the time currently used in infantry trials. It is assumed that the actual time would be a distribution with the current value as the mean, but that using this value is acceptable for the type of weapons currently being assessed, and over the typical ranges over which close combat occurs.

Further development of the CCSM and SSM and the underlying suppression criteria will focus on this issue.

Further applications of the criteria

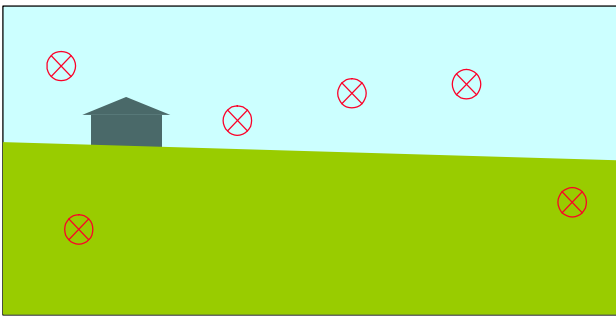
The initial use of the criteria has been to assist in the recent studies of the balance between suppression and incapacitation capabilities required by the infantry section in various scenarios. However, there are a number of other ways that the criteria can be used to optimise weapon system performance.

The first area is that of Operations Other Than War (OOTW). The requirements here are often for systems that can achieve a mission with the minimum amount of collateral damage. The problem lies in the fact that any response to a hostile act (ie coming under sniper attack) has usually led to some kind of lethal response, with the attendant risk of collateral damage.

The suppression criteria described could be used to redesign or modify current weapon systems to maximise their suppressive capability, without increasing their lethal capability. This may well

then allow peacekeeping troops to repulse hostile forces without the high level of damage that is often associated with current systems.

Alternatively, it may be possible to use the criterion to develop fire control solutions for weapon systems to maximise suppressive potential for a given target size and number, and the particular phase of the support mission. For instance, against a section deployed in a 50m by 50m area, aiming marks can be injected into the sight at differing points at set time intervals to ensure that at least one round landed within the suppressive radius of each target within the area to ensure constant suppression throughout a time period.



The solution could also modify the time interval throughout the engagement to take into account the proximity of troops being supported. The rate of fire, or burst length could also be controlled to maximise effect for minimum ammunition usage.

This criteria was developed primarily to investigate direct fire suppression by small arms. In this it appears to be very successful, having produced results that support the views of soldiers about certain weapons which previously could not be scientifically corroborated. By expanding the incapacitation criterion to include blast and tertiary injury (eg due to collapsing trenches) it may be possible to include the indirect fire suppression that leads to PTSD.

Finally, suppression is particularly difficult to counter. The level of incapacitation suffered by a soldier can be decreased by increasing or redistributing his protection. To reduce suppression, however, it is necessary to reduce

awareness of risk, but this would have the side effect of reducing the awareness of most other things as well. Thus, whilst small calibre bursting munitions could be made less lethal by the use of simple overhead protection, their suppressive effects would remain largely unaffected.

Summary

Suppression is the means by which soldiers are able to get close enough to the enemy to inflict casualties. Although the lethality of infantry weapon systems is increasing, the actual numbers of casualties they will cause in the long term is unlikely to increase significantly. This is because any potential enemy will take steps to reduce their effectiveness (through tactics or equipment). This will be reinforced by the natural reaction of enemy soldiers to take whatever steps are necessary to stay in the battle for as long as possible. Thus suppression will remain the principle means of enabling the infantry to close with the enemy.

The suppression criteria developed within DERA allows the suppressive capability of weapon systems to be modelled, and assessed in trials for close combat systems. Initial trials to validate the criteria and methodology have been very encouraging. There is scope for this criteria to be extended to allow assessment of the capability of indirect fire systems also.

The use of this criteria to maximise suppressive capability would have utility to weapon systems for both general war and OOTW.

As a last thought, the history of weapons development has seen the application of different types of fundamental elements to weapons. First came muscle power, thrusting the sword, throwing the spear and pulling the bow-string. This was followed by the use of elements and compounds with through varying types of interaction brought about chemical propulsion (and missiles, fragments and vehicles). The middle of this century saw the deployment of the energy within the atom in the form of the nuclear bomb, followed by the use of the electrons in all manner of

communications devices, sensors and possibly weapons. Developing suppressive capability into weapons from the outset will be amongst the first conscious effort to make use of the neurone (ie the fundamental particle within the brain) as a defeat mechanism.

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